09:41:44 OCA PAD INITIATION - PROJECT HEADER INFORMATION 10/07/87

Active

Project #: E-25-M28 Cost share #: Rev #: 0
Center # : R6394-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: E-12821 Mod #: Document : PO
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: ME Unit code: 02.010.126
Project director(s):
KAHN B ME

Sponsor/division names: GEORGIA POWER COMPANY /
Sponsor/division codes: 256 / 004

Award period: 870901 to 881231 (performance) 881231 (reports)

Sponsor amount	New this change	Total to date
Contract value	19,200.00	19,200.00
Funded	19,200.00	19,200.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: CALIBRATION OF BETA-PARTICLE DETECTOR FOR STRONTIUM-89 AND STRONTIUM-90

PROJECT ADMINISTRATION DATA

OCA contact: Brian J. Lindberg 894-4820

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Sponsor issuing office

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ATLANTA, GEORGIA 30332-0420

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A N/A supplemental sheet
Equipment title vests with: Sponsor GIT
NONE PROPOSED OR ANTICIPATED.

Administrative comments -
INITIATION OF PROJECT E-25-M28.

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 11/11/88

Project No. E-25-M28 / R6394-0A0 School/Lab ME

Includes Subproject No.(s) N/A

Project Director(s) B. Kahn GTRC/GTRI

Sponsor Georgia Power Company

Title Calibration of Beta-Particle Detector for Strontium-89 and Strontium - 90

Effective Completion Date: 12/31/88 (Performance) 12/31/88 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Copy of Last Invoice Serving as Final
- [ ] Release and Assignment
- [ ] Final Report of Inventions and/or Subcontract: N/R
  Patent and Subcontract Questionnaire sent to Project Director [ ]
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Continues Project No. _____ Continued by Project No. _____

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Technical Completion Report
for Project E-25-M28
for the Georgia Power Co.

Calibration of Beta - Particle Detector for Strontium-89 and Strontium-90

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School of Mechanical Engineering
Georgia Institute of Technology

October 1988

Introduction

Environmental radiological monitoring at nuclear power plants requires measurement of radiostrontium in samples of surface water, ground water and milk. The two strontium radionuclides of specific interest are strontium-89 (50.5 day half-life, 1.49 Mev max. beta particles) and strontium-90 (28.8 year half-life, 0.546 Mev max. beta particles). Analysis of these two radionuclides is more difficult than that of most other fission and activation products at nuclear power stations because they two do not emit gamma rays which permit non-destructive analysis. Radiostrontium must be chemically separated from the sample and then counted with a beta-particle detector. The detector used is a gas-flow proportional counter with anticoincidence background subtraction and automatic sample changer.

The detector must be calibrated for counting efficiency in order to convert the count rate to a disintegration rate in units such as disintegrations per minute, picocuries, or becquerel (disintegrations per second), so that results can be reported in terms of these values per liter or kilogram. Calibration is performed with standard solutions of strontium-89 and strontium-90 counted under the same conditions as the samples.

The counting efficiencies for strontium-89 (Sr-89), strontium-90 (Sr-90), and the yttrium-90 (Y-90) daughter of the latter must be determined precisely because all three radionuclides are measured in the same sample and must be distinguished by their radioactive ingrowth and decay patterns. Any error in the determination of one results in an opposite error in the calculated activity of the other. That is, if Sr-89 is underestimated, Sr-90 will be overestimated. Furthermore, the counting efficiency of each radionuclide depends on the sample mass, hence efficiency values must be determined for the entire range of possible sample weights.

The activity of Sr-90 and Y-90 can be determined in a sample by first chemically separating strontium and then measuring the beta-particle activity on two occasions. The first count is due to Sr-90 with a minimal count contributed by Y-90. If the sample is then measured two weeks later, the Y-90 (64.2 hour half-life, 2.28 MeV max. beta particles) daughter of Sr-90 will have grown into the sample according to a defined growth rate and the Sr-90 will have essentially remained constant.

The counting samples are conventionally prepared with a strontium "carrier" which is added at the beginning of the separation process as a measured reagent volume with known amount of activity of standardized strontium solution. The purified strontium samples are weighed before counting. The advantage of this procedure is that the recovery of strontium is determined by comparing the final weight to that of the initially added strontium, thus monitoring any losses and permitting compensation for such losses.

Self Absorption of Beta Particles

Whenever the beta activities of samples of finite thickness are measured, consideration should be given to the effect of absorption of electrons in the samples themselves. To make correction for this effect negligible, the sample thickness should be no more than about one percent of the range of the electrons. Thin samples make it possible to have only a small self-absorption correction, and it is usually necessary to arrange that samples are spread uniformly over the sample-mounting area. [1] In this experiment, filtration is performed on a small tared sintered glass crucible filter which gives reasonable uniform deposits of precipitates on the filter paper. The precipitate has a surface area of 2.27 cm^2

For the measurement of soft beta radiation from an appreciably thick sample, it is theoretically possible to calculate the effect of absorption of the radiation in the sample (self-absorption); however, no rigorous calculation is practical because it would require that the absorption curve for the radiation, the thickness of the sample, the solid angle subtended by the counter and the back-scattering effect be taken into account. If possible, the samples should be made less thick than the half-thickness value for the radiation. When thicker samples must be used, it is advisable either to standardize the thickness at a fixed value or to prepare an empirical calibration curve for different thicknesses.[1]

Work with appreciable thick samples is most frequently necessary for the low-energy beta emitters, especially C-14 and S-35. When thicker and thicker samples are prepared from an active material--for example, $BaC0^3$ containing C-14--the measured counting rate at first increases because of the greater total activity in the sample and then approaches a constant value.[1]

1. Gerhart Friedlander and Joseph W. Kennedy, Introduction To Radiochemistry, PP. 229, 231, New York, John Wiley and Sons, INC., 1949.

Procedure - $Sr(NO3)2$ Carrier + Sr-89 tracer:

1) X* ml aliquot of carrier is pipetted into each tube

2) 0.5 ml of Sr-89 tracer is added

3) Solution is diluted up to 20 ml with deionized water

4) 0.5 ml of 1N NaOH is added

5) 1.5 ml of 3N Na_2CO_3 is added

6) The mixture is heated and stirred for 20 min.

7) The solution is cooled and then centrifuged and the supernatant is discarded

8) The precipitate (ppt) is washed with water and then centrifuged, and the supernatant is discarded

9) The ppt is suspended in water and collected on a tared membrane filter (Gelman) of 25 mm diameter and 0.45-um pore size in a sintered glass crucible.

10) The ppt is washed with water, 95% Ethanol, and ether.

11) The ppt dried under a heat lamp, let cool to room temperature, and weighed.

12) The ppt is mounted on a plastic disk of 0.1 cm thickness which is covered with mylar (1.7 mg/cm^2), and sealed with a plastic ring.

13) The ppt is is placed in a stainless steel holder in the detector. Beta particles are counted with a Tennelec X-B LB-5100 detector.

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* X=0.1 ml, 0.2ml, 0.4ml, 0.6ml, 0.8ml, 1.0ml, 1.25ml, 1.50ml, 1.75 ml and 2.0 ml.

Dilution of Sr-89 tracer

Bottle # 2462-1

Activity of the tracer as of 10/23/1987 was 72.9 nCi/gm. 1.0167 gm of the solution had been removed by the Georgia Power Co. Lab. Received 3.21 ml of the solution. The original solution was 5.0 gm (5ml).

3.21 + 1.0167=4.2267 ml of the tracer
5 gm x 72.9 nCi/gm = 364.5 nCi

Concentration after correction for weight loss

$$= \frac{364.5 \text{ nCi}}{} = 86.24 \text{ nCi/ml}$$

(as of 10/23/1987)

$$A=Ae^{-lt} \quad = 86.24 \text{ nCi } e^{\frac{(-0.693 \times 164)}{50.5}} = 9.085 \text{ nCi/ml}$$

(as of 4/4/1988)

$$(\text{concentration})_A \ (\text{Volume})_A = (\text{concentration})_B \ (\text{volume})_B$$

$$(9.085 \text{ nCi/ml}) \ (3.21 \text{ ml}) = (\text{concentration})_B \ (50. \text{ml})$$

$$(\text{concentration})_B = \frac{(9.085 \text{ nCi/ml})(3.21 \text{ ml})}{50 \text{ ml}}$$

$$= 0.583 \text{ nCi/ml} = 583 \text{ pCi/ml}$$

(As of 4/4/1988)

Procedure - $Sr(NO3)2$ carrier + Sr-90 tracer:

1. To a 100-ml water sample, X* ml of $Sr(NO_3)_2$ carrier and 1 ml of barium carrier (16 mg/ml) are added.

2. Make basic with a few drops of 1 N NaOH to phenolphthalein endpoint and then heat.

3. Add 5 ml of 1.5 m Na_2CO_3, stir and digest until $SrCO_3$ coagulates, and cool overnight. Decant as much liquid as possible, then collect precipitate by centrifuging; discard supernatant.

4. Wash precipitate with 15 ml water and discard wash solution.

5. Dissolve precipitate with 1 ml 6 N HN03.

6. Add 25 ml 16N HN03, stir, and cool in an ice bath for 5 minutes.

7. Centrifuge, discard supernant.

8. Dissolve precipitate with 10 ml water and add 0.5 ml 0.1 M $FeCl_3$.

9. Heat the solution to near boiling in water bath and add 6 N NH40H dropwise until $Fe(OH)_3$ precipitates.

10. Cool, centrifuge, and transfer supernant to a clean centrifuge tube. Discard precipitate. Note time of last precipitation; this is the beginning of yttrium ingrowth. Complete steps 11 through 18 without delay to minimize ingrowth of Y-90.

11. Add 3 drops methyl red indicator, and adjust pH to near 5 with a few ml of 1 N HCl. (Color change is from yellow to red.)

12. Add 5 ml ammonium acetate buffer solution and heat in water bath.

13. Slowly add 1 ml of 0.5 M Na_2Cr0_4. stir, heat, and centrifuge. Transfer supernatant to a clean centrifuge tube; discard residue.

14. Add 2 ml of 15 N NH_4OH to the supernatant, heat in water bath, and slowly add, with stirring, 5 ml of 1.5 M Na_2C0_3. Digest until precipitation is complete, cool, centrifuge, and discard supernatant.

15. Dissolve precipitate with 5 ml of 1 N HCl, add 10 ml water, and repeat step 14.

and discard wash solution.

17. Slurry the precipitate with minimum amount of water, transfer to a tared sintered glass crucible and collect on a Gelman membrane filter of 25 mm diameter and pore size 0.45 um pore size.

18. Wash the precipitate with water, 95% ethanol, and ether.

19. Weigh the precipitate and mount it on a plastic disk (0.1 cm thickness), covered with mylar (1.7 mg/cm2), and sealed with a plastic ring.

20. Count the precipitate immediately for beta particles. The sample is placed in a stainless steel holder and counted with a Tennelec X-B LB-5100 detector.

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* = 0.1ml, 0.2ml, 0.4ml, 0.6ml, 0.8ml, 1.0ml, 1.25ml, 1.50ml, 1.75ml, and 2.0ml.

Dilution of Sr-90 tracer:

Bottle #2019-10

Activity of the tracer as of 6/15/1987 was 4.48 nCi/gm. 2 ml of this solution was taken and diluted to 50 ml. The original solution was 5 ml (5gm).

$(\text{concentration})_A(\text{volume})_A = (\text{concentration})_B(\text{volume})_B$

$(4.48\ \text{nCi/ml})(2\ \text{ml}) = (\text{concentration})_B(50\ \text{ml})$

$(\text{concentration})_B = \frac{4.48 \times 2}{50} = 179.2\ \text{pCi/ml}$ as of (6/15/1987)

Results

Georgia Power Co. and Georgia Tech Environmental Radiation Lab. results are tabulated in Appendix A and B respectively for Sr-89. Appendix C and D contain results of Sr-90 and Y-90 for Georgia Power and Georgia Tech respectively.

Sr-89: Counting efficiency increases slightly as the weight of precipitate increases from about 3.5mg (0.1 ml) to 6.5mg (0.2 ml), but then decreases slowly with increase in precipitate weight. This result is observed both in Georgia Power and Georgia Tech detectors. Plotted graphs are average of at least three data points. Some points have not been used in average calculation, if those points were three standard deviation (± 30) from the mean value.

Sr-90: Counting efficiency increases sharply as the weight of precipitate increases from about 2.5 mg (0.1 ml carrier) to 5 mg (0.2 ml carrier), but then it decreases steadily with increase in precipitate weight. All the average data points except the ones for 5 mg (0.2 ml carrier) and 11 mg(0.4 ml carrier) fall within 0.25-1.5% of the plotted curve. One needs to have more data points at 0.2 ml and 0.4 ml carrier in order to determine how the efficiency behaves at these values. Fortunately, the amount of carrier that is normally used is greater than the above values, at well-defined efficiency values. Results from the Georgia Power detector and Georgia Tech are similar. Plotted on graphs are averages of three data points.

Y-90: Counting efficiency increases sharply as the weight of precipitate increases from 2.5 mg(0.1 ml carrier) to 5 mg (0.2 ml carrier), but then remains constant with increase in precipitate weight. All the average data points except the ones for 5 mg (0.2 ml carrier) and 11 mg (0.4 ml carrier) fall within 0.25-1.5% of the plotted curve. One needs to have more data points at 0.2 ml and 0.4 ml carrier in order to determine exactly how the efficiency behaves at these values. The amount of carrier that is mostly used is greater than these values. Results from the Georgia Power detector and the Georgia Tech detector are similar. Plotted graphs are average of three data points except for 1.25 ml carrier. One of the data points at 1.25 ml had to be discarded since it did not fall within $\pm$ 35 of the mean.

Conclusion

In summary, the % efficiency for Sr-90 is much lower than it is for Sr-89. Efficiency for Y-90 is higher than it is for Sr-90, may be lower at range 0.1-0.4 ml carrier than it is for Sr-89, but it then exceeds Sr-89 efficiency when more than 0.4 ml of carrier is used. This finding is observed both in Georgia Power and Georgia Tech detectors.

The yield for Sr-90 was lower than it is for Sr-89 because there are many more steps in the Sr-90 procedure than there are for Sr-89. Therefore, there is a tendency for lower recovery for Sr-90.

References

Gerhart Friedlander and Joseph W. Kennedy, Introduction to Radiochemistry, New York, John Wiley and Sons, Inc., 1949.

Gerhart Friedlander and Joseph W. Kennedy, Nuclear and Radiochemistry, New York, John Wiley and Sons, Inc., 1955.

M.L. Wiedenbeck, "The Absolute Strength of Radioactive Sources," Phys. Rev. 72, 974(1947).*

P.E. Yankwich and J.W. Weigl, "The Relation of Backscattering to Self-Absorption in Routing Beta-Ray Measurements," Science 107, 651(1948).*

L.R. Zumwalt, "Absolute Beta Counting Using End-Window Geiger-Mueller Counter Tubes," U.S. Atomic Energy Commission Declassified Document MDDC-1346.*

* The above sources were not found at the Georgia Tech library.

APPendix A

GA Power Results (SR-89)

$Sr(NO_3)_2$ carrier + Sr-89 tracer :

GA Power Detector-

Sample	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (ε)
1 5/9/1988	0.1	3.39	96.6	180.85	49.1
2 5/17/1988	"	3.90	>100	169.32	—
3 5/24/1988	"	3.69	100	146.41	44.5
4 6/14/1988	"	3.56	100	115.69	48.8
5 6/24/1988	"	3.60	100	99.51	48.7

Counting time = 100 min.

Sample Calculation:

Average Gross Count = 180.85 CPM

BKG Count = 1.22 CPM

Counting time = 100 min

% Yield = 96.6

$$\epsilon = \frac{180.25 - 1.22}{(0.966)(291.5\ Pci)(2.22)\left(e^{\frac{-0.693 \times 39}{50.5}}\right)} = 49.1\ \%$$

$Sr(No3)_2$ Carrier + Sr-89 tracer :

GA Power Detector—

Sample	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (ε)
1 (4/12/1988)	0.2	6.16	87.8	161.85	50.3
2 (4/15/1988)	〃	6.65	94.8	187.17	49.7
3 (4/18/1988)	〃	6.81	97.0	198.02	49.3
4 (6/14/1988)	〃	7.13	100	115.26	48.6
5 (6/24/1988)	〃	6.77	96.5	101.14	51.3

Counting time = 100 min.

Sample Calculation:

Average Gross Count = 161.85 CPM

BKG Count = 1.21 CPM

Counting time = 100 min.

% yield = 87.8

$$\epsilon = \frac{161.85 - 1.21}{(0.878)(291.5\ \text{PCi})(2.22)\left(e^{\frac{-0.693 \times 42}{50.5}}\right)} = 50.3\%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer :

GA Power Detector-

sample	Carrier (ml)	Weight of precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (E)
* 1 (4/12/88)	0.4	13.44	95.7	169.75	48.4
2 (4/15/88)	"	13.71	97.7	181.01	46.6
3 (4/18/88)	"	13.54	96.5	196.52	49.2
4 (4/29/88)	"	16.40	>100	—	—
5 (4/29/88)	"	14.57	>100	—	—
6 (4/29/88)	"	15.27	>100	—	—
7 (5/2/88)	"	13.76	98.0	211.67	49.4
8 (5/2/88)	"	13.85	98.7	211.81	49.1
9 (5/2/88)	"	14.03	99.9	208.29	47.6

* A small amount of sample was lost during mounting. Counting time = 100 min.

* This sample was not used to plot

xmple Calculation:

Average Gross Count = 181.01 CPM

BKG Count = 1.19 CPM

Counting time = 100 min.

% yield = 97.7

$$\epsilon = \frac{181.01 - 1.19}{(0.977)(291.5\ \mu Ci)(2.22)\left(e^{\frac{-0.693 \times 36}{50.5}}\right)} = 46.6\ \%$$

$Sr(No3)_2$ Carrier + Sr-89 tracer :

GA Power Detector-

sample (Date)	Carrier (ml)	Weight of precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (ϵ)
1 (4/12/88)	0.6	20.21	96.0	170.04	48.4
2 (4/15/88)	"	20.45	97.1	184.42	47.8
3 (4/18/88)	"	20.36	96.7	193.46	48.3
4 (6/24/88)	"	20.56	97.6	101.15	50.8

Counting time = 100 min.

Sample calculation:

Average Gross Count = 170.04 CPM

BKG Count = 1.21 CPM

Counting time = 100 min

% yield = 96.0

$$\epsilon = \frac{170.04 - 1.21}{(0.96)(291.5\ \text{PCi})(2.22)\left(e^{\frac{-0.693 \times 42}{50.5}}\right)} =$$

$Sr(No3)_2$ Carrier + Sr-89 tracer:

GA Power Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CMP)	% Efficiency (ϵ)
1 (4/12/88)	0.8	26.93	95.9	165.40	47.0
2 (4/15/88)	〃	27.45	97.8	180.30	46.4
* 3 (4/18/88)	〃	27.43	97.7	181.03	44.7
4 (4/29/88)	〃	27.48	97.9	181.39	49.2
5 (4/29/88)	〃	27.59	98.3	182.51	49.3

* A small amount of sample was lost during mounting.
Counting time = 100 min.

* This sample was not used to plot

Sample calculation:

Average Gross Count = 165.4 CPM

BKG Count = 1.21 CPM

Counting time = 100 min

% yield = 95.9

$$\epsilon = \frac{165.4 - 1.21}{(0.959)(291.5\,\text{PCi})(2.22)\left(e^{\frac{-0.693 \times 42}{50.5}}\right)} = 47.0\ \%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Power Detector-

Sample (Date)	Carrier (mg)	Weight of Precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (ε)
1 (5,9,88)	1.0	35.12	100	179.85	47.1
2 (5,16,88)	〃	35.19	100	164.42	46.1
* 3 (5,17,88)	〃	34.49	98.3	155.29	44.9
4 (5,24,88)	〃	34.03	97.0	146.51	46.0
5 (5,24,88)	〃	34.75	99.0	146.7	47.0

* A small amount of sample was lost during mounting.
Counting time = 100 min.

* This sample was not used to plot

Sample Calculation:

Average Gross Count = 164.42 CPM

BKG Count = 1.22 CPM

Counting time = 100 min.

% yield = 100

$$\epsilon = \frac{164.42 - 1.22}{(1)(291.5\ \mu Ci)(2.22)(e^{\frac{-0.693 \times 44}{50.5}})} = 46.1\ \%$$

$Sr(NO_3)_2$ carrier + Sr-89 tracer:

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CMP)	% Efficiency (E)
1 (5/9/88)	1.25	43.91	100	175.93	46.1
2 (5/10/88)	〃	42.93	97.9	163.11	45.5
3 (5/16/88)	〃	44.27	100.9	—	—
4 (5/24/88)	〃	42.65	97.2	143.9	46.9
5 (6/14/88)	〃	43.60	99.4	107.65	45.6

Counting time = 100 min.

Sample calculation:

Average Gross Count = 175.93 CPM

BKG Count = 1.22 CPM

Counting time = 100 min.

% yield = 100

$$\epsilon = \frac{175.93 - 1.22}{(1)(291.5\ \text{PCi})(2.22)\left(e^{\frac{-0.693 \times 39}{50.5}}\right)} = 46.1\ \%$$

$Sr(No_3)_2$ carrier + Sr-89 tracer:

GA Power Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (E)
* 1 (5/9/88)	1.5	52.08	98.9	168.84	44.7
2 (5/10/88)	s	52.49	99.7	161.74	44.3
3 (5/16/88)	s	51.86	98.5	160.95	45.8
4 (5/24/88)	s	51.26	97.4	140.36	45.7
5 (5/24/88)	s	52.33	99.4	142.57	45.5

* A small amount of sample was lost during mounting. Counting time = 100 min.

* This sample was not used to plot

Sample Calculation:

Average Gross count = 161.74 CPM

BKG Count = 1.21 CPM

Counting time = 100 min

% yield = 99.7

$$\epsilon = \frac{161.74 - 1.21}{(0.997)(291.5\,\mu Ci)(2.22)\left(e^{-\frac{0.693 \times 42}{50.5}}\right)} = 44.3\ \%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Power Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (E)
1 (5/10/88)	1.75	60.31	98.2	155.80	43.3
2 (5/17/88)	〃	60.41	98.4	155.12	44.8
* 3 (5/24/88)	〃	60.86	99.1	136.47	43.6
4 (6/14/88)	〃	60.83	99.1	104.36	44.4
5 (6/24/88)	〃	60.93	99.2	91.38	45.1

* The sample had to be remounted on the ring at GA Power lab, because it was not flat; therefore, there was some loss of the sample. Counting time = 100 min.

* This sample was not used to plot

Sample Calculation:

Average Gross Count = 155.80 CPM

BKG Count = 1.21 CPM

Counting time = 100 min.

% yield = 98.2

$$\epsilon = \frac{155.80 - 1.21}{(0.982)(291.5\ pCi)(2.22)\left(e^{\frac{-0.693 \times 42}{50.5}}\right)} = 43.3\%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of precipitate (mg)	% yield	Average Gross Count (CPM)	% Efficiency (E)
1 (5/10/88)	2.0	69.34	98.8	154.88	42.8
* 2 (5/16/88)	"	70.30	100.2	154.17	43.2
* 3 (5/17/88)	"	69.20	98.6	143.74	41.4
4 (5/24/88)	"	69.60	99.2	138.26	44.2
5 (6/14/88)	"	69.60	99.2	101.50	43.1

* A small amount of sample was lost during mounting.
Counting time = 100 min.

* These samples were not used to plot

Sample Calculation:

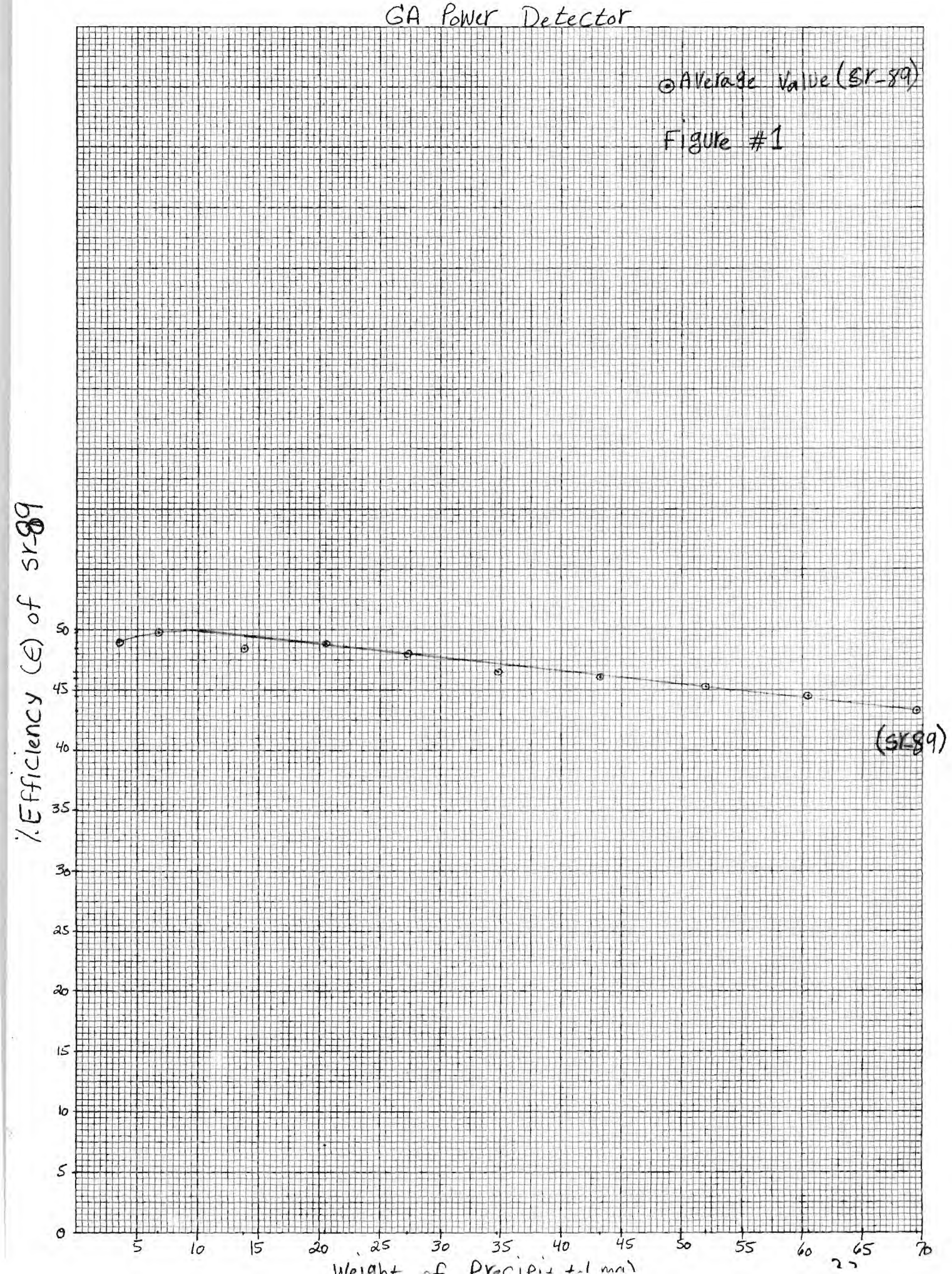
Average Gross count = 154.88 CPM

BKG count = 1.21 CPM

Counting time = 100 min.

% yield = 98.8

$$\epsilon = \frac{154.88 - 1.21}{(0.988)(291.5\ \text{PCi})(2.22)\left(e^{\frac{-0.693 \times 42}{50.5}}\right)} = 42.8\%$$


GA Power Detector
⊙ Average Value (Sr-89)
Figure #1
% Efficiency (ε) of Sr-89
(Sr-89)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70

APPendix B

GA Tech Results (SR-89)

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector–

Sample	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (50 min)	% Efficiency (ε)
1 5/9/1988	0.1	3.39	96.6	7234	48.18
* 2 5/17/1988	"	3.90	>100	7160.5	46.07
3 5/24/1988	"	3.69	100	6400.66	45.32
4 6/14/1988	"	3.56	100	5036.5	46.01
5 6/24/1988	"	3.60	100	4989.25	47.02

* This sample was not used to plot

Sample Calculation:

Total Gross Count = 7234
BKG = 56
Counting time = 50 min.
% yield = 96.6

$$\epsilon = \frac{7234 - 56}{(0.966)(291.5\,\text{Pci})(2.22)\left(e^{\frac{-0.693}{50.5} \times 54}\right)(50\,\text{min})} = 48.18\%$$

$Sr(No_3)_2$ Carrier + Sr-89 tracer :

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (100 min)	% Efficiency (ε)
1 (4/12/1988)	0.2	6.16	87.8	24690	50.3
2 (4/15/88)	〃	6.65	94.8	23045	44.1
3 (4/18/1988)	〃	6.81	97.0	23918	47.9
4 (6/14/1988)	〃	7.13	100	* 5129.5	46.9
5 (6/24/1988)	〃	6.77	96.5	* 5120.5	50.0

* They were counted for 50 min.

Sample calculation:

Total Gross count = 24690

BKG = 127

Counting time = 100 min.

% yield = 87.8

$$\epsilon = \frac{24690 - 127}{(0.878)(291.5\,\mu Ci)(2.22)\left(e^{-\frac{0.693 \times 11}{50.5}}\right)(100)} = 50.3\%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% Yield	Total Gross Count (50 min)	% Efficiency (ε)
* 1 (4/12/88)	0.4	13.44	95.7	+24,007	44.8
2 (4/15/88)	〃	13.71	97.7	+21,346	39.6
3 (4/18/88)	〃	13.54	96.5	+24,207	48.7
4 (4/29/88)	〃	16.40	>100	10,669.5	—
5 (4/29/88)	〃	14.57	>100	10,553	—
6 (4/29/88)	〃	15.27	>100	10,349.5	—
7 (5/2/88)	〃	13.76	98.0	9,446.25	46.6
8 (5/2/88)	〃	13.85	98.7	9,809.25	48.0
9 (5/2/88)	〃	14.03	99.9	9,469.5	45.8

* A small amount of sample was lost during mounting.

+ They were counted for 100 min.

* This sample was not used to plot

Sample Calculation:

Total Gross Count = 21,346

BKG = 110

Counting time = 100 min

% yield = 97.7

$$\epsilon = \frac{21{,}346 - 110}{(0.977)(291.5\ \text{Pci})(2.22)(e^{\frac{-0.693 \times 12}{50.5}})(100\ \text{min})} = 39.6\%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (100 min)	% Efficiency (E)
1 (4/12/88)	0.6	20.21	96.0	24,201	45.1
+ 2 (4/15/88)	"	20.45	97.1	21,678	41.0
3 (4/18/88)	"	20.36	96.7	23,464.5	47.1
4 (6/24/88)	"	20.56	97.6	* 4,975.75	48.0

* It was counted for 50 min.

+ It was not used to plot

Sample Calculation:

Total Gross Count = 24,201

BKG = 127

Counting time = 100 min.

% yield = 96.0

$$\epsilon = \frac{24{,}201 - 127}{(0.96)(291.5\ \text{Pci})(2.22)\left(e^{\frac{-0.693 \times 11}{505}}\right)(100\ \text{min})} = 45.1\ \%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (100 min)	% Efficiency (ε)
1 (4/12/88)	0.8	26.93	95.9	25,432	47.4
⊗ 2 (4/15/88)	〃	27.45	97.8	21,747	40.9
* 3 (4/18/88)	〃	27.43	97.7	21,771	43.2
4 (4/29/88)	〃	27.48	97.9	+ 10,287.5	48.1
5 (4/29/88)	〃	27.59	98.3	+ 10,250	47.7

* A small amount of sample was lost during mounting.
+ They were counted for 50 min.
* This sample was not used to plot
⊗ It was not used to plot

Sample Calculation:

Total Gross Count = 25,432

BKG = 127

Counting time = 100 min

% yield = 96.0

$$\epsilon = \frac{25{,}432 - 127}{(0.96)(291.5\,\mu Ci)(2.22)\left(e^{\frac{-0.693 \times 11}{50.5}}\right)(100\,min)} = 47.4\,\%$$

$Sr(NO_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (mg)	Weight of Precipitate (mg)	% yield	Total Gross Count (50 min)	% Efficiency (ε)
1 (5/9/88)	1.0	35.12	100	7,062.5	45.4
2 (5/16/88)	〃	35.19	100	6,911	43.8
* 3 (5/17/88)	〃	34.49	98.3	6,628	—
4 (5/24/88)	〃	34.03	97.0	6,366.66	46.5
5 (5/24/88)	〃	34.75	99.0	6,491	47.1

* A small amount of sample was lost during mounting.

* It was not used to Plot

Sample Calculation:

Total Gross Count = 7,062.5

BKG Count = 56

Counting time = 50 min.

% Yield = 100

$$\epsilon = \frac{7{,}062.5 - 56}{(1)(291.5\,\text{PCi})(2.22)\left(e^{\frac{-0.693 \times 54}{50.5}}\right)(50\ \text{min.})} = 45.4\%$$

$Sr(No_3)_2$ carrier + Sr-89 tracer:

GA Tech Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (50 min)	% Efficiency (E)
1 (5/9/88)	1.25	43.91	100.1	7,004	45.0
2 (5/10/88)	〃	42.93	97.9	6,784.5	44.0
3 (5/16/88)	〃	44.27	100.9	—	—
4 (5/24/88)	〃	42.65	97.2	6,151.33	44.8
5 (6/14/88)	〃	43.60	99.4	4,897.5	45.0

Sample Calculation:

Total Gross count = 7,004
BKG count = 56
Counting time = 50 min.
% yield = 100

$$\epsilon = \frac{7{,}004 - 56}{(1)(291.5\,\text{PCi})(2.22)(e^{\frac{-0.693 \times 54}{50.5}})(50\,\text{min})} = 45.0\%$$

$Sr(No_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (50 min)	% Efficiency (E)
* 1 (5/9/88)	1.5	52.08	98.9	6,739	43.8
2 (5/10/88)	〃	52.49	99.7	6,849	43.7
3 (5/16/88)	〃	51.86	98.5	6,839	44.0
4 (5/24/88)	〃	51.26	97.4	6,165.33	44.8
5 (5/24/88)	〃	52.33	99.4	6,329.66	45.7

* A small amount of sample was lost during mounting.
* This sample was not used to Plot

· Sample Calculation:

Total Gross Count = 6,849

BKG Count = 42

Counting time = 50 min

% yield = 99.7

$$\epsilon = \frac{6{,}849 - 42}{(0.997)(291.5\ \text{PCi})(2.22)\left(e^{\frac{-0.693 \times 53}{50.5}}\right)(50\ \text{min})} = 43.7\%$$

$Sr(No_3)_2$ Carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Carrier (mg)	% yield	Total Gross Count (50 min)	% Efficiency (E)
1 (5/10/88)	1.75	60.31	98.2	6,660	43.1
2 (5/17/88)	"	60.41	98.4	6,799.5	44.4
* 3 (5/24/88)	"	60.86	99.1	5,968	43.3
4 (6/14/88)	"	60.83	99.1	4,760	43.8
5 (6/24/88)	"	60.93	99.2	4,604.25	43.7

* The sample had to be remounted on the ring at GA Power lab, because it was not flat; therefore, there was some loss of the sample.

* This sample was not used to Plot

∴ Sample Calculation:

Total Gross count = 6,660

BKG count = 42

Counting time = 50 min.

% Yield = 98.2

$$\epsilon = \frac{6{,}660 - 42}{(0.982)(291.5\ \text{pCi})(2.22)\left(e^{\frac{-0.693 \times 53}{50.5}}\right)(50\ \text{min})} = 43.1\ \%$$

$Sr(NO_3)_2$ carrier + Sr-89 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Gross Count (50 min)	% Efficiency (ε)
1 (5/10/88)	2.0	69.34	98.8	6,621.5	42.6
* 2 (5/16/88)	"	70.30	100.2	6,614.5	41.9
* 3 (5/17/88)	"	69.20	98.6	6,307.5	41.1
4 (5/24/88)	"	69.60	99.2	6,011.33	43.5
5 (6/14/88)	"	69.60	99.2	4,679	43.0

* A small amount of sample was lost during mounting.

* These samples were not used to Plot

Sample Calculation:

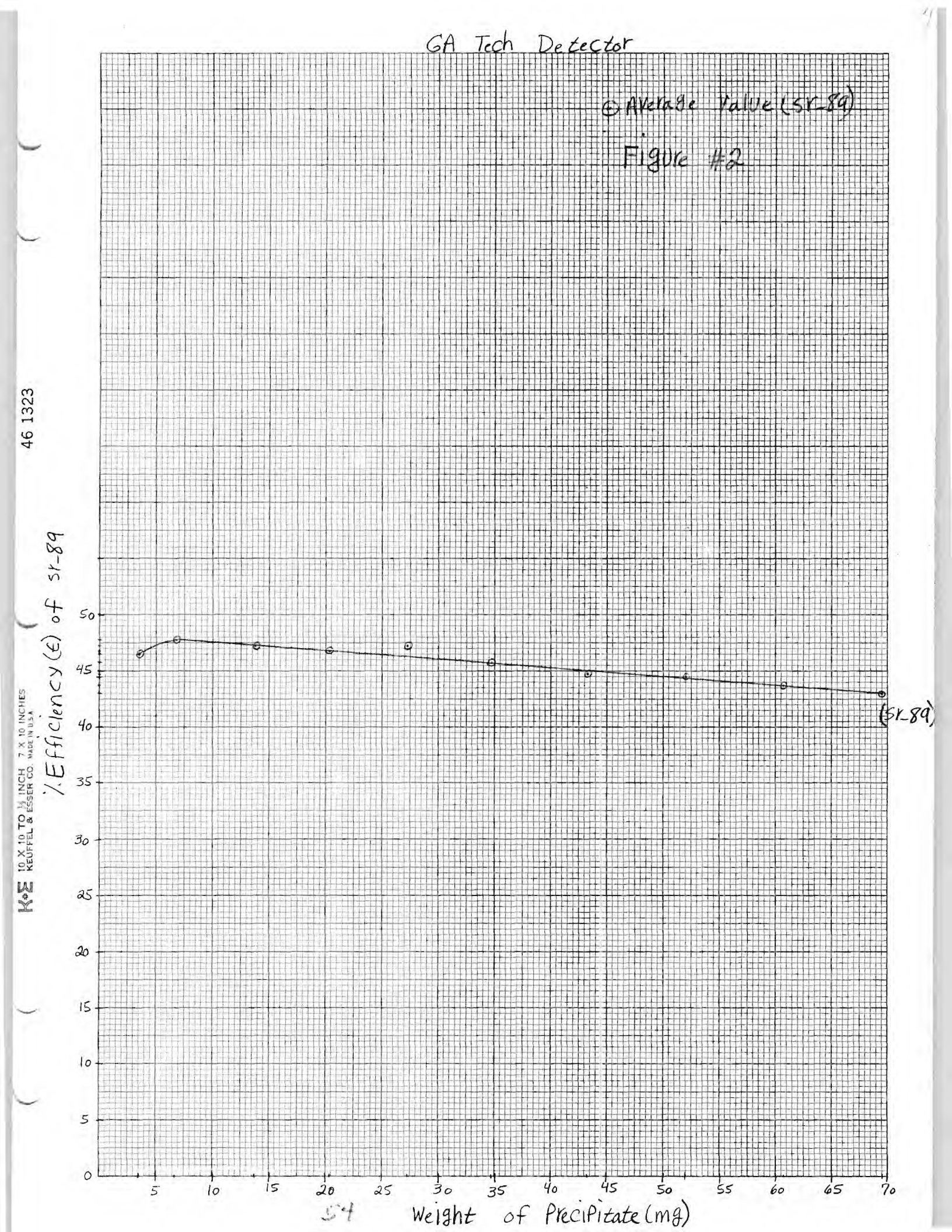
Total Gross Count = 6,621.5

BKG Count = 42

Counting time = 50 min.

% yield = 98.8

$$\epsilon = \frac{6{,}621.5 - 42}{(0.988)(291.5\,\text{pCi})(2.22)\left(e^{\frac{-0.693 \times 53}{50.5}}\right)(50\,\text{min})} = 42.6\%$$


GA Tech Detector
⊕ Average Value (Sr-89)
Figure #2
% Efficiency (ε) of Sr-89
0
5
10
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35
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45
50
5
10
15
20
25
30
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45
50
55
60
65
70
(Sr-89)
Weight of Precipitate (mg)
54
46 1323
K&E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Appendix C

GA Power Results (sr-90 and y-90)

$Sr(No_3)_2$ Carrier + Sr-90 tracer :

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time(t_i) (hr)
* 1 (7,14,88)	0.1	4.79	>100	—	—
2 (7,17,88)	s	2.77	78.9	78.38	7.93
+ 3 (7,21,88)	s	1.17	33.3	—	—
4 (7,28,88)	s	2.55	72.65	83.84	7.52
5 (8,25,88)	s	2.61	74.36	80.96	8.1

* It was not used to Plot

+ low yield, It was not used to Plot

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
1 (7/14/88)	0.1	—	—	—	—
2 (7/17/88)	5	158.12	425.42	22.89	28.75
3 (7/21/88)	5	—	—	—	—
4 (7/28/88)	5	166.94	462.83	26.87	32.30
5 (8/25/88)	5	160.02	438.92	25.22	30.35

Sample Calculation :

Initial Gross count (CPM) = 78.38

Initial Time (t_i) = 7.93 hr

Final Gross count (CPM) = 158.12

Final Time (t_f) = 425.42 hr

Activity of sr-90 (A_{sr-90}) = 387.22 dpm/ml

% yield = 78.9

$$A_{sr-90} = (179.2\ \text{pCi/ml})\left(e^{\frac{-(0.693)(407)}{28.6\times365}}\right)(2.22\ \text{dpm/pCi}) = 387.22\ \text{dpm/ml}$$

$BKG_i = 1.23$ CPM , $BKG_f = 158.12$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of}\ y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of}\ y}}\right)$$

$R_i = 78.38 - 1.23 = 77.15$ CPM

$R_f = 158.12 - 1.22 = 156.9$ CPM

① $$\frac{77.15}{(387.22)(0.789)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(7.93)}{64.2}}\right)$$

② $$\frac{156.9}{(387.22)(0.789)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(425.42)}{64.2}}\right)$$

① $\times -1$ $\{0.2525231 = \epsilon_{sr} + 0.0820382\ \epsilon_y\}$

② $0.5135564 = \epsilon_{sr} + 0.9898689\ \epsilon_y$

$0.2610333 = 0.9078307\ \epsilon_y$

$\epsilon_y = 28.75\ \%$
$\epsilon_{sr} = 22.89\ \%$

$Sr(No3)_2$ Carrier + Sr-90 tracer :

GA Power Detector—

Sample (Date)	Carrier (ml)	Weight of precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time(t_i) (hr)
1 (7/14/88)	0.2	4.48	63.8	95.25	13.02
2 (7/21/88)	〃	4.11	58.5	89.24	9.32
3 (8/25/88)	〃	6.19	88.18	120.01	11.48

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7/14/88)	0.2	183.08	492.92	32.67	41.12
2 (7/21/88)	"	178.50	368.30	34.60	44.51
3 (8/25/88)	"	236.38	442.25	30.33	39.07

Sample Calculation :

Initial Gross Count (CPM) = 95.25

Initial Time (t_i) = 13.02 hr

Final Gross count (CPM) = 183.08

Final Time (t_f) = 492.92 hr

Activity of sr-90 (A_{sr-90}) = 387.30 dpm/ml

% yield = 63.8

$$A_{sr-90} = (179.2\ Pci/ml)\left(e^{\frac{-(0.693)(404)}{28.6 \times 365}}\right)(2.22\ dpm/Pci) = 387.30\ dpm/ml$$

$BKG_i = 1.19$ CPM, $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of } y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of } y}}\right)$$

$R_i = 95.25 - 1.19 = 94.06$ CPM

$R_f = 183.08 - 1.22 = 181.86$ CPM

① $$\frac{94.06}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(13.02)}{64.2}}\right)$$

② $$\frac{181.86}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(492.92)}{64.2}}\right)$$

① $-1\{0.3806596 = \epsilon_{sr} + 0.1311136\ \epsilon_y\}$

② $0.735985 = \epsilon_{sr} + 0.995111\ \epsilon_y$

$0.3553254 = 0.8639974\ \epsilon_y$

$\epsilon_y = 41.12\ \%$
$\epsilon_{sr} = 32.67\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer:

GA Power Detector-

sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (t_i) (hr)
1 (7,7,88)	0.4	10.14	72.24	96.22	9.1
2 (7,14,88)	"	11.48	81.77	125.71	16.35
* 3 (8,25,88)	"	—	—	—	—
4 (9,1,88)	"	11.67	83.12	115.69	7.37

* sample was lost while centrifuging.

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
1 (7/7/88)	0.4	198.33	439.42	30.14	40.63
2 (7/14/88)	s	242.74	494.58	32.15	44.33
* 3 (8/25/88)	s	—	—	—	—
4 (9/1/88)	s	239.30	456.60	32.45	42.06

Sample Calculation :

Initial Gross Count (CPM) = 96.22

Initial Time (t_i) = 9.1 hr

Final Gross Count (CPM) = 198.33

Final Time (t_f) = 439.42 hr

Activity of Sr-90 (A_{sr_90}) = 387.48 dpm/ml

% yield = 72.24

$$A_{sr\_90} = (179.2\ pCi/ml)\left(e^{\frac{-(0.693)(397)}{28.6 \times 365}}\right)(2.22\ dpm/pCi) = 387.48\ dpm/ml$$

$BKG_i = 1.21$ CPM , $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of } y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of } y}}\right)$$

$R_i = 96.22 - 1.21 = 95.01$ CPM

$R_f = 198.33 - 1.22 = 197.11$ CPM

① $$\frac{95.01}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(9.1)}{64.2}}\right)$$

② $$\frac{197.11}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(439.42)}{64.2}}\right)$$

① $\times -1$ $\{ 0.3394238 = \epsilon_{sr} + 0.0935586\ \epsilon_y \}$

② $0.7041766 = \epsilon_{sr} + 0.9912899\ \epsilon_y$

$0.3647528 = 0.8977313\ \epsilon_y$

$\epsilon_y = 40.63\ \%$
$\epsilon_{sr} = 30.14\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer :

GA Power Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time(t_i) (hr)
1 (7,7,88)	0.6	16.25	77.18	116.51	12.43
2 (7,14,88)	〃	15.14	71.89	125.91	19.68
3 (8,25,88)	〃	17.78	84.42	133.39	14.82

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7/7/88)	0.6	239.64	442.75	32.58	47.53
2 (7/14/88)	〃	237.60	496.25	35.25	49.89
3 (8/25/88)	〃	261.72	445.60	33.64	46.64

Sample Calculation :

Initial Gross Count (CPM) = 116.51

Initial Time (t_i) = 12.43 hr

Final Gross Count (CPM) = 239.64

Final Time (t_f) = 442.75 hr

Activity of Sr-90 (A_{sr_90}) = 387.48 dPM/ml

% yield = 77.18

$A_{sr\_90} = (179.2\ PCi/ml)\left(e^{\frac{-(0.693)(397)}{28.6 \times 365}}\right)(2.22\ dPM/PCi) = 387.48\ dPM/ml$

$BKG_i = 1.21$ CPM, $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-6.693)(t_f)}{t_{1/2}\ \text{of y}}}\right)$$

$R_i = 116.51 - 1.21 = 115.3$ CPM

$R_f = 239.64 - 1.22 = 238.42$ CPM

① $$\frac{115.3}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(12.43)}{64.2}}\right)$$

② $$\frac{238.42}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(442.75)}{64.2}}\right)$$

① $-1\{0.3855232 = \epsilon_{sr} + 0.1255623\ \epsilon_y\}$

② $0.7971938 = \epsilon_{sr} + 0.9915974\ \epsilon_y$

$0.4116706 = 0.8660351\ \epsilon_y$

$\epsilon_y = 47.53\ \%$
$\epsilon_{sr} = 32.58\ \%$

Sr(No3)2 Carrier + Sr-90 tracer :

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (ti) (hr)
1 (7/7/88)	0.8	21.66	77.16	116.07	15.76
2 (7/21/88)	"	21.92	78.10	113.16	10.98
3 (9/1/88)	"	24.83	88.43	134.73	10.72

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7/7/88)	0.8	232.43	446.08	31.13	46.58
2 (7/21/88)	"	243.44	369.13	31.48	49.55
3 (9/1/88)	"	288.92	458.27	33.52	51.13

Sample Calculation :

Initial Gross Count (CPM) = 116.07

Initial Time (t_i) = 15.76 hr

Final Gross Count (CPM) = 231.21

Final Time (t_f) = 446.08 hr

Activity of Sr-90 (A_{sr-90}) = 387.48 dpm/ml

% yield = 77.16

$$A_{sr-90} = (179.2\ \text{pCi/ml})\left(\frac{-(0.693)(397)}{e^{28.6 \times 365}}\right)(2.22\ \text{dpm/pCi}) = 387.48\ \text{dpm/ml}$$

BKG_i = 1.21 CPM, BKG_f = 1.22 CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of y}}}\right)$$

$R_i = 116.07 - 1.21 = 114.86$ CPM

$R_f = 232.43 - 1.22 = 231.21$ CPM

① $$\frac{114.86}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(15.76)}{64.2}}\right)$$

② $$\frac{231.21}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(446.08)}{64.2}}\right)$$

① $\times -1$ { $0.3841516 = \epsilon_{sr} + 0.1564361\ \epsilon_y$ }

② $0.7732865 = \epsilon_{sr} + 0.9918941\ \epsilon_y$

$0.3891349 = 0.835458\ \epsilon_y$

$\epsilon_y = 46.58\ \%$
$\epsilon_{sr} = 31.13\ \%$

$Sr(No3)_2$ Carrier + Sr-90 tracer :

GA Power Detector–

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time(t_i) (hr)
1 (7,7,88)	1.0	29.39	83.76	126.03	19.1
* 2 (7,21,88)	〃	28.80	82.05	—	—
3 (7,28,88)	〃	29.88	85.13	117.86	9.18
4 (9,1,88)	〃	31.38	89.40	132.64	14.05

* A little of Ppt. was lost while mounting.

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_F) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
1 (7,7,88)	1.0	249.74	449.42	29.64	47.29
* 2 (7,21,88)	"	—	—	—	—
3 (7,28,88)	"	263.44	464.5	30.77	49.16
4 (9,1,88)	"	272.44	459.93	31.28	47.65

Sample Calculation :

Initial Gross Count (CPM) = 126.03

Initial Time (t_i) = 19.1 hr

Final Gross Count (CPM) = 249.74

Final Time (t_f) = 449.42 hr

Activity of sr-90 (A_{sr-90}) = 387.48 dpm/ml

% yield = 83.76

$$A_{sr-90} = (179.2\ pci/ml)\left(e^{\frac{-(0.693)(397)}{28.6 \times 365}}\right)(2.22\ dpm/pci) = 387.48\ dpm/ml$$

$BKG_i = 1.21$ CPM, $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of}\ y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of}\ y}}\right)$$

$R_i = 126.03 - 1.21 = 124.82$ CPM

$R_f = 249.74 - 1.22 = 248.52$ CPM

① $$\frac{124.82}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(19.1)}{64.2}}\right)$$

② $$\frac{248.52}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(449.42)}{64.2}}\right)$$

① $-1\{0.3845683 = \epsilon_{sr} + 0.1863076\ \epsilon_y\}$

② $0.765686 = \epsilon_{sr} + 0.9921811\ \epsilon_y$

$0.381177 = 0.8058735\ \epsilon_y$

$\epsilon_y = 47.29$ %
$\epsilon_{sr} = 29.64$ %

Sr(No3)2 Carrier + Sr-90 tracer :

GA Power Detector—

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (t_i) (hr)
1 (7,11,88)	1.25	40.95	93.3	107.38	7.78
2 (7,17,88)	〃	38.68	88.2	116.38	9.6
3 (9,1,88)	〃	40.82	93.04	132.23	17.37

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7,11,88)	1.25	241.28	418.85	26.09	40.77
2 (7,17,88)	"	263.08	427.08	28.97	48.18
3 (9,1,88)	"	280.10	461.60	27.91	50.09

Sample Calculation :

Initial Gross Count (CPM) = 107.38

Initial Time (t_i) = 7.78 hr

Final Gross Count (CPM) = 241.28

Final Time (t_f) = 418.85 hr

Activity of Sr-90 (A_{Sr-90}) = 387.37 dpm/ml

% yield = 93.3

$$A_{Sr-90} = (179.2\ \text{Pci/ml})\left(\frac{-(0.693)(401)}{e^{28.6 \times 365}}\right)(2.22\ \text{dpm/Pci}) = 387.37\ \text{dpm/ml}$$

$BKG_i = 1.22$ CPM , $BKG_f = 1.23$ CPM

① $$\frac{K_i}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of}\ y}}\right)$$

② $$\frac{R_f}{(A_{Sr})(\text{yield of Sr})} = \epsilon_{Sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of}\ y}}\right)$$

$R_i = 107.38 - 1.22 = 106.16$ CPM

$R_f = 241.28 - 1.23 = 240.05$ CPM

① $$\frac{106.16}{(387.37)(0.933)} = \epsilon_{Sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(7.78)}{64.2}}\right)$$

② $$\frac{240.05}{(387.37)(0.933)} = \epsilon_{Sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(418.85)}{64.2}}\right)$$

① $\times -1$ $\{ 0.2937333 = \epsilon_{Sr} + 0.0805506\ \epsilon_y \}$

② $0.6641926 = \epsilon_{Sr} + 0.9891243\ \epsilon_y$

$0.3704593 = 0.9085737\ \epsilon_y$

$\epsilon_y = 40.77$ %
$\epsilon_{Sr} = 26.09$ %

Calculation of standard deviation (σ):

%E = 40.77, 48.18, 50.09

Range = 50.09 − 48.18 = 1.91

$\text{Mean} = \frac{48.18 + 50.09}{2} = 49.13$

σ = (Range)(multiplying factor)

= (1.91)(0.886) = 1.69

Mean $\pm 3\sigma = 49.13 \pm 3(1.69) \Longrightarrow$ 54.2, 44.06

since 40.77 does not fall within these two values, it can be discarded.

multiplying factor = 0.886 for two measurements, from NCRP report #58, P. 316.

Sr(No3)2 carrier + Sr-90 tracer :

GA Power Detector—

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (t_i) (hr)
* 1 (7,11,88)	1.50	53.65	>100	—	—
2 (7,17,88)	5	45.64	86.7	112.70	11.27
+ 3 (7,28,88)	5	44.12	83.80	—	—
4 (9,6,88)	5	45.82	87.03	153.08	32.97
5 (9,6,88)	5	42.92	81.52	137.52	34.63

(*, +) They were not used to Plot.

+ It was only counted for 30 min. due to some problem with Power.

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (tf) (hr)	% Efficiency (ε) of Sr-90	% Efficiency (ε) of Y-90
* 1 (7/11/88)	1.50	—	—	—	—
2 (7/17/88)	"	256.36	428.33	27.60	48.87
+ 3 (7/28/88)	"	—	—	—	—
4 (9/6/88)	"	259.44	345.42	31.21	46.81
5 (9/6/88)	"	242.72	347.08	27.64	50.32

(*, +) They were not used to Plot.

Sample Calculation :

Initial Gross Count (CPM) = 112.70

Initial Time (t_i) = 11.27 hr

Final Gross count (CPM) = 256.36

Final Time (t_f) = 428.33 hr

Activity of sr-90 (A_{sr-90}) = 387.22 dpm/ml

% yield = 86.7

$$A_{sr-90} = (179.2\ \text{pCi/ml})\left(e^{\frac{-(0.693)(407)}{28.6 \times 365}}\right)(2.22\ \text{dpm/pCi}) = 387.22\ \text{dpm/ml}$$

$BKG_i = 1.23$ CPM, $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of y}}}\right)$$

$R_i = 112.70 - 1.23 = 111.47$ CPM

$R_f = 256.36 - 1.22 = 255.14$ CPM

① $$\frac{111.47}{(387.22)(0.867)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(11.27)}{64.2}}\right)$$

② $$\frac{255.14}{(387.22)(0.867)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(428.33)}{64.2}}\right)$$

①−1 $\{0.3320329 = \epsilon_{sr} + 0.1145442\ \epsilon_y\}$

② $0.7599791 = \epsilon_{sr} + 0.9901822\ \epsilon_y$

$0.4279462 = 0.875638\ \epsilon_y$

$\epsilon_y = 48.87\ \%$
$\epsilon_{sr} = 27.60\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer :

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (t_i) (hr)
* 1 (7,11,88)	1.75	62.13	>100	—	—
2 (7,17,88)	"	54.73	89.1	113.32	12.93
3 (9,6,88)	"	53.15	86.53	146.96	36.3
4 (9,6,88)	"	55.32	90.06	148.42	37.97

* It was not used to Plot

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
* 1 (7/11/88)	1.75	—	—	—	—
2 (7/17/88)	"	257.74	430.01	26.14	48.53
3 (9/6/88)	"	253.28	348.75	27.84	48.78
4 (9/6/88)	"	265.28	350.42	24.73	52.46

Sample Calculation :

Initial Gross count (CPM) = 113.32

Initial Time (t_i) = 12.93 hr

Final Gross count (CPM) = 257.74

Final Time (t_f) = 430.01 hr

Activity of sr-90 (A_{sr-90}) = 387.22 dpm/ml

% yield = 89.1

$$A_{sr-90} = (179.2\ \text{pCi/ml})\left(e^{-\frac{(0.693)(407)}{28.6\times 365}}\right)(2.22\ \text{dpm/pCi}) = 387.22\ \text{dpm/ml}$$

$BKG_i = 1.23$ CPM , $BKG_f = 1.22$ CPM

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\ \text{of}\ y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\ \text{of}\ y}}\right)$$

$R_i = 113.32 - 1.23 = 112.09$ CPM

$R_f = 257.74 - 1.22 = 256.52$ CPM

① $$\frac{112.09}{(387.22)(0.891)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(12.93)}{64.2}}\right)$$

② $$\frac{257.74}{(387.22)(0.891)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(430.01)}{64.2}}\right)$$

① $-1\{0.3246254 = \epsilon_{sr} + 0.1302691\ \epsilon_y\}$

② $0.7420009 = \epsilon_{sr} + 0.9903586\ \epsilon_y$

$0.4173755 = 0.8600895\ \epsilon_y$

$\epsilon_y = 48.53\ \%$
$\epsilon_{sr} = 26.14\ \%$

Sr(NO3)2 Carrier + Sr-90 tracer :

GA Power Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Initial Gross Count (CPM)	Initial Time (t_i) (hr)
1 (7/11/88)	2.0	67.51	96.2	104.56	10.28
* 2 (7/28/88)	s	61.41	87.48	127.78	—
3 (9/6/88)	s	63.04	89.80	147.76	39.38
4 (9/6/88)	s	65.64	93.50	155.34	41.05

* a little bit of ppt. was lost while mounting

Sample (Date)	Carrier (ml)	Final Gross Count (CPM)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7,11,88)	2.0	254.56	423.85	22.95	45.50
* 2 (7,28,88)	"	257.32	—	—	—
3 (9,6,88)	"	257.86	351.83	24.87	50.32
4 (9,6,88)	"	261.00	353.5	25.82	47.23

Sample Calculation :

Initial Gross Count (CPM) = 104.56

Initial Time (t_i) = 10.28 hr

Final Gross count (CPM) = 254.56

Final Time (t_f) = 423.85 hr

Activity of sr-90 ($A_{sr\text{-}90}$) = 387.37 dPM/ml

% yield = 96.2

$$A_{sr\text{-}90} = (179.2\ \text{pCi/ml})\left(e^{\frac{-(0.693)(401)}{28.6\times365}}\right)(2.22\ \text{dPM/pCi}) = 387.37\ \text{dPM/ml}$$

$BKG_i = 1.22$ CPM , $BKG_f = 1.23$ CPM

$$\text{①}\quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$\text{②}\quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$R_i = 104.56 - 1.22 = 103.34$ CPM

$R_f = 254.56 - 1.23 = 253.33$ CPM

$$\text{①}\quad \frac{103.34}{(387.37)(0.962)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(10.28)}{64.2}}\right)$$

$$\text{②}\quad \frac{253.33}{(387.37)(0.962)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(423.85)}{64.2}}\right)$$

$$\text{①}\times(-1)\quad 0.2773111 = \epsilon_{sr} + 0.1050311\ \epsilon_y$$

$$\text{②}\quad 0.6798069 = \epsilon_{sr} + 0.9896958\ \epsilon_y$$

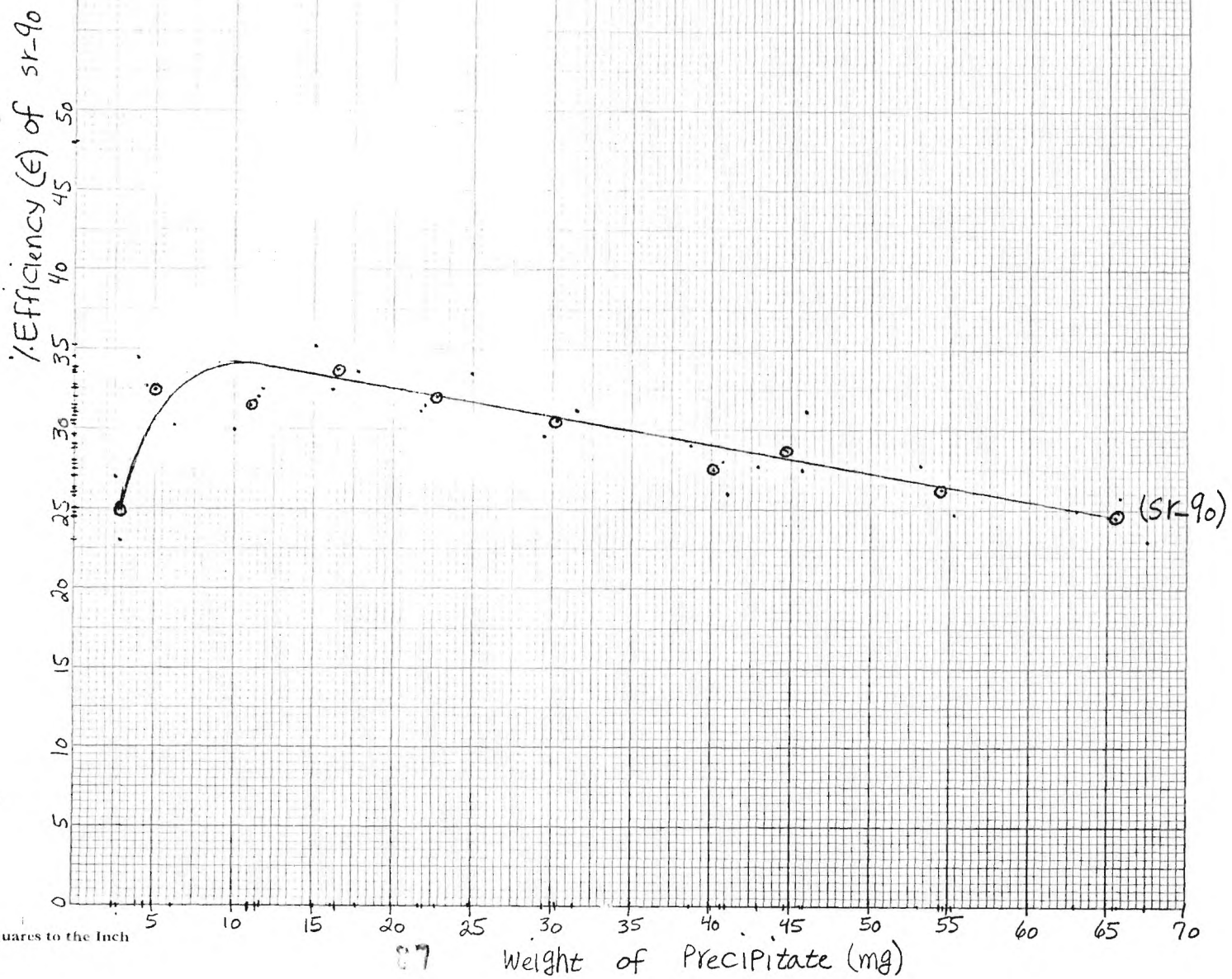
$$0.4024958 = 0.8846647\ \epsilon_y$$

$\epsilon_y = 45.50\ \%$
$\epsilon_{sr} = 22.95\ \%$

GA Power Detector

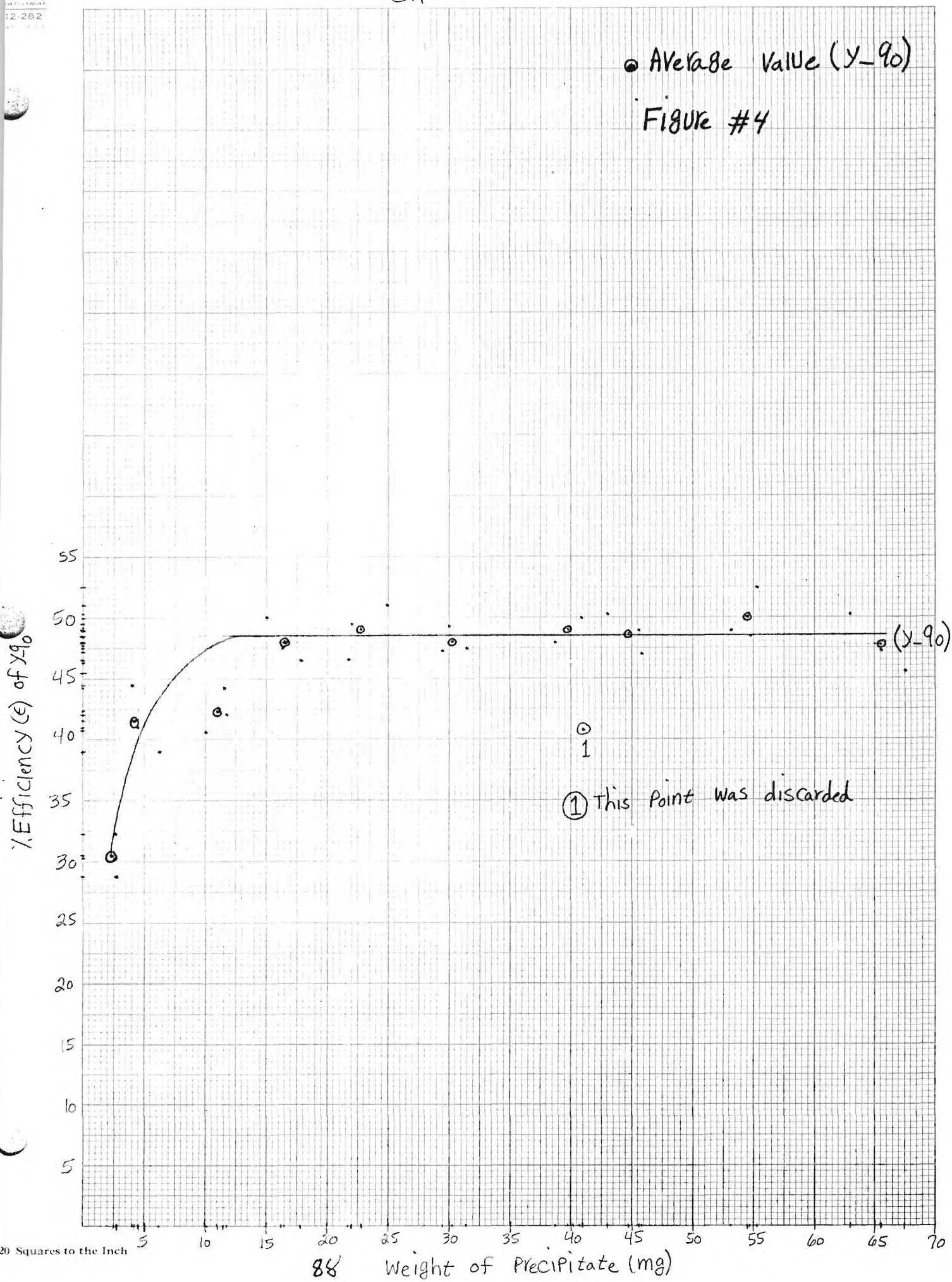
⊙ Average Value (Sr-90)

Figure #3



20 Squares to the Inch

GA Power Detector



20 Squares to the Inch

GA Power Detector

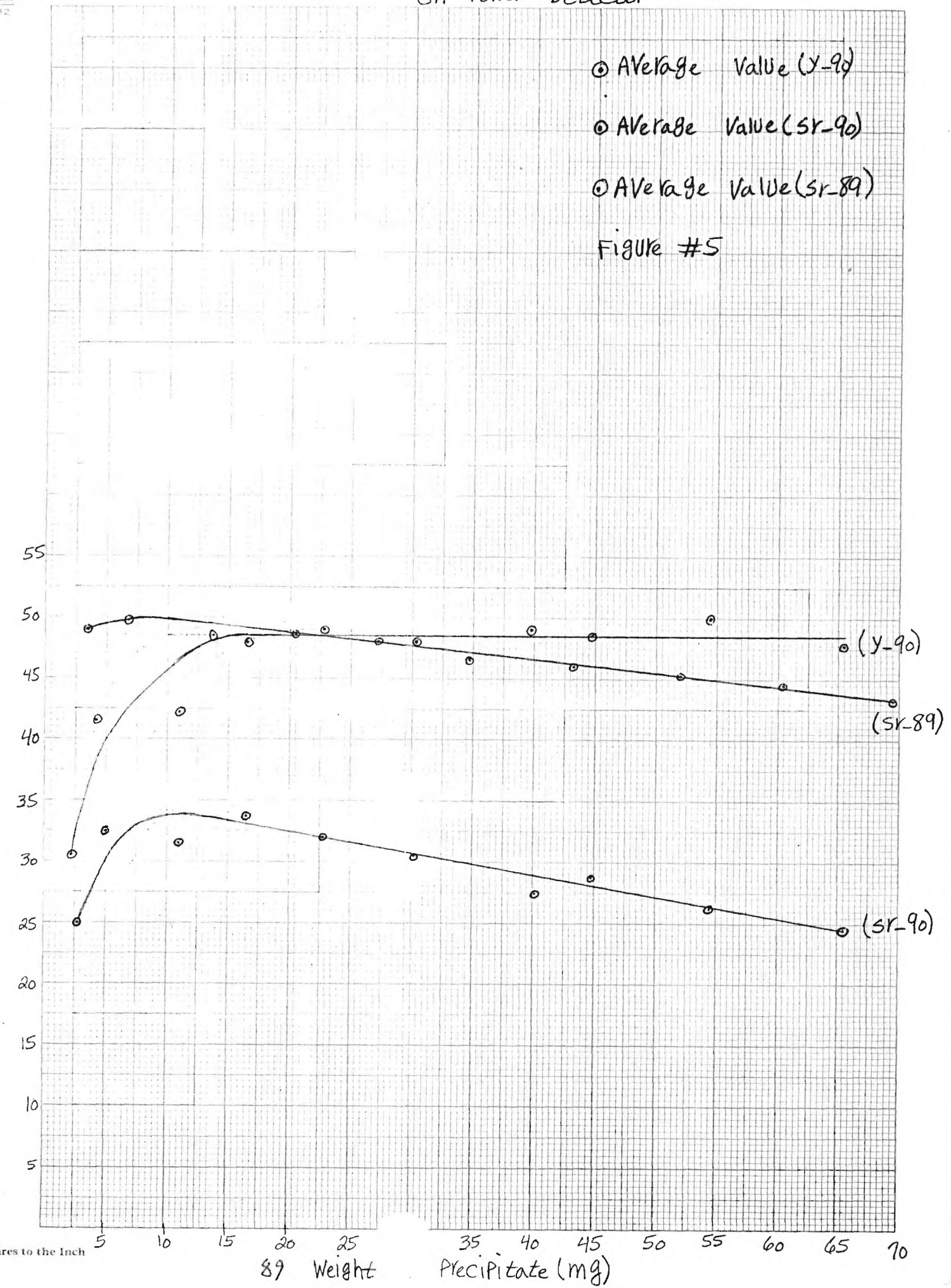


Figure #5

20 Squares to the Inch

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GA Tech ResUlts (sr-90 and y-90)

$Sr(NO_3)_2$ Carrier + Sr-90 tracer :

GA Tech Detector

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time(t_i) (hr)
* 1 (7/14/88)	0.1	4.79	> 100	—	—
2 (7/17/88)	"	2.77	78.9	3684	4.5
+ 3 (7/21/88)	"	1.17	33.3	—	—
4 (7/28/88)	"	2.55	72.65	3825	5.92
5 (8/25/85)	"	2.61	74.36	3708	3.78

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
* 1 (7,14,88)	0.1	—	—	—	—
2 (7,17,88)	"	7465	464.48	22.57	26.18
+ 3 (7,21,88)	"	—	—	—	—
4 (7,28,88)	"	7976	446.02	24.90	31.83
5 (8,25,88)	"	7441	419.5	24.37	27.40

Sample Calculation :

Total Initial Gross Count = 3684

Initial Time (t_i) = 4.5 hr

Total Final Gross Count = 7465

Final Time (t_f) = 464.48 hr

Activity of Sr-90 ($A_{sr\text{-}90}$) = 387.22 dpm/ml

% yield = 78.9

$$A_{sr\text{-}90} = (179.2\ pCi/ml)\left(e^{-\frac{(0.693)(407)}{28.6\times 365}}\right)(2.22\ dpm/pCi) = 387.22\ dpm/ml$$

$BKG_i = 46.25$, $BKG_f = 44.25$

$$① \quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$② \quad \frac{R_f}{(A_{sr})(\text{yield of y})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{3684 - 46.25}{50} = 72.75 \text{ CPM}$$

$$R_f = \frac{7465 - 44.25}{50} = 148.41 \text{ CPM}$$

$$① \quad \frac{72.75}{(387.22)(0.789)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(4.5)}{64.2}}\right)$$

$$② \quad \frac{148.41}{(387.22)(0.789)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(464.48)}{64.2}}\right)$$

$$① \times -1\left\{0.2381212 = \epsilon_{sr} + 0.0474138\,\epsilon_y\right\}$$

$$② \quad 0.4857674 = \epsilon_{sr} + 0.9933542\,\epsilon_y$$

$$0.2476462 = 0.9459404\,\epsilon_y$$

$\epsilon_y = 26.18\%$
$\epsilon_{sr} = 22.57\%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer :

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
1 (7/14/88)	0.2	4.48	63.8	4008	5.85
2 (7/21/88)	s	4.11	58.5	4112	4.78
3 (8/25/88)	s	6.19	88.18	5306	4.63

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7,14,88)	0.2	8513	485.18	29.67	39.03
2 (7,21,88)	"	8570	363.1	33.75	42.40
3 (8,25,88)	"	11334	420.33	28.96	37.71

Sample Calculation :

Total Initial Gross Count = 4008

Initial Time (t_i) = 5.85 hr

Total Final Gross Count = 8513

Final Time (t_f) = 485.18 hr

Activity of sr-90 (A_{sr-90}) = 387.30 dpm/ml

% yield = 63.8

$$A_{sr-90} = (179.2\ pCi/ml)\left(e^{\frac{-(0.693)(404)}{28.6\times365}}\right)(2.22\ dpm/pCi) = 387.30\ dpm/ml$$

$BKG_i = 47.20$, $BKG_f = 50.66$

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{4008 - 47.20}{50} = 79.22 \quad CPM$$

$$R_f = \frac{8513 - 50.66}{50} = 169.25 \quad CPM$$

① $$\frac{79.22}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(5.85)}{64.2}}\right)$$

② $$\frac{169.25}{(387.30)(0.638)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(485.18)}{64.2}}\right)$$

① $-1\{\ 0.3205861 = \epsilon_{sr} + 0.0611947\ \epsilon_y\ \}$

② $$0.6849525 = \epsilon_{sr} + 0.994685\ \epsilon_y$$

$$0.3643664 = 0.9334903\ \epsilon_y$$

$\epsilon_y = 39.03\ \%$
$\epsilon_{sr} = 29.67\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time(t_i) (hr)
1 (7/7/88)	0.4	10.14	72.24	4701	8.18
2 (7/14/88)	〃	11.48	81.77	5479	6.7
* 3 (8/25/88)	〃	—	—	—	—
4 (9/1/88)	〃	11.67	83.12	5141	3.93

* sample was lost while centrifuging

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f), (hr)	% Efficiency (ϵ) of Sr	% Efficiency (ϵ) of Y
1 (7,7,88)	0.4	9532	435.25	30.01	38.05
2 (7,14,88)	"	11797	486.03	31.30	43.12
* 3 (8,25,88)	"	—	—	—	—
4 (9,1,88)	"	11411	447.33	30.02	41.12

Sample Calculation :

Total Initial Gross Count = 4701

Initial Time (t_i) = 8.18 hr

Total Final Gross Count = 9532

Final Time (t_f) = 435.25 hr

Activity of Sr-90 (A_{sr-90}) = 387.48 dPM/ml

% yield = 72.24

$$A_{sr-90} = (179.2\ Pci/ml)\left(e^{\frac{-(0.693)(397)}{28.6\times365}}\right)(2.22\ dPM/Pci) = 387.48\ dPM/ml$$

$BKG_i = 50.37$, $BKG_f = 54.6$

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of } y}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of } y}}\right)$$

$$R_i = \frac{4701 - 50.37}{50} = 93.01\ CPM$$

$$R_F = \frac{9532 - 54.6}{50} = 189.55$$

① $$\frac{93.01}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(8.18)}{64.2}}\right)$$

② $$\frac{189.55}{(387.48)(0.7224)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(435.25)}{64.2}}\right)$$

① $-1\{0.3322787 = \epsilon_{sr} + 0.084512\ \epsilon_y\}$

② $0.6771685 = \epsilon_{sr} + 0.9908888\ \epsilon_y$

$0.3448898 = 0.9063767\ \epsilon_y$

$\epsilon_y = 38.05\ \%$
$\epsilon_{sr} = 30.01\ \%$

Sr(NO3)2 Carrier + Sr-90 tracer:

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
1 (7/7/88)	0.6	16.25	77.18	5249	7.33
2 (7/14/88)	"	15.14	71.89	5326	7.53
3 (8/25/88)	"	17.78	84.42	5639	5.47

Sample (Date)	Carrier	Total Final Gross Count (50 min)	Final Time (t_f), (hr)	% Efficiency (ϵ) of sr	% Efficiency (ϵ) of y
1 (7,7,88)	0.6	11493	436.083	31.29	45.61
2 (7,14,88)	〃	11483	486.87	34.15	48.22
3	〃	12877	421.17	31.54	47.67

Sample Calculation :

Total Initial Gross Count = 5249

Initial Time (t_i) = 7.33 hr

Total Final Gross Count = 11493

Final Time (t_f) = 436.08 hr

Activity of sr-90 (A_{sr-90}) = 387.48 dPM/ml

% yield = 77.18

$$A_{sr-90} = (179.2\ PCi/ml)\left(e^{-\frac{(0.693)(397)}{28.6\times 365}}\right)(2.22\ dPM/PCi) = 387.48\ dPM/ml$$

$BKG_i = 50.37$ CPM, $BKG_f = 54.6$ CPM

$$\text{①}\quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$\text{②}\quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{5249 - 50.37}{50} = 103.97 \text{ CPM}$$

$$R_f = \frac{11493 - 54.6}{50} = 228.77 \text{ CPM}$$

$$\text{①}\quad \frac{103.97}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(7.33)}{64.2}}\right)$$

$$\text{②}\quad \frac{228.77}{(387.48)(0.7718)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(436.08)}{64.2}}\right)$$

$$\text{①}-1\quad \{0.3476483 = \epsilon_{sr} + 0.0760736\,\epsilon_y\}$$

$$\text{②}\quad 0.7649209 = \epsilon_{sr} + 0.9909704\,\epsilon_y$$

$$0.4172726 = 0.9148968\,\epsilon_y$$

$\epsilon_y = 45.61\ \%$
$\epsilon_{sr} = 31.29\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer :

GA Tech Detector-

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% Yield	Total Initial Gross Count (50 min)	Initial Time(ti) (hr)
1 (7/7/88)	0.8	21.66	77.16	4988	6.5
2 (7/21/88)	"	21.92	78.10	4994	7.12
3 (9/1/88)	"	24.83	88.43	5930	4.77

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (tf), (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
1 (7/7/88)	0.8	11264	436.93	29.95	45.44
2 (7/21/88)	"	11551	363.93	29.17	47.90
3 (9/1/88)	"	13851	448.17	31.98	49.27

Sample Calculation :

Total Initial Gross Count = 4988

Initial Time (t_i) = 6.5 hr

Total Final Gross count = 11264

Final Time (t_f) = 436.93 hr

Activity of sr-90 (A_{sr-90}) = 387.48 dPM/ml

% yield = 77.16

$$A_{sr-90} = (179.2\ Pci/ml)\left(e^{\frac{-(0.693)(397)}{28.6 \times 365}}\right)(2.22\ dPM/Pci) = 387.48\ dPM/ml$$

$BKG_i = 50.37$, $BKG_f = 54.6$

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{4988 - 50.37}{50} = 98.75 \quad CPM$$

$$R_f = \frac{11264 - 54.6}{50} = 224.19 \quad CPM$$

① $$\frac{98.75}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(6.5)}{64.2}}\right)$$

② $$\frac{224.19}{(387.48)(0.7716)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(224.19)}{64.2}}\right)$$

① $\times -1$ $\{ 0.330278 = \epsilon_{sr} + 0.0677586\ \epsilon_y \}$

② $0.7498013 = \epsilon_{sr} + 0.9910526\ \epsilon_y$

$0.4195233 = 0.923294\ \epsilon_y$

$\epsilon_y = 45.44\ \%$
$\epsilon_{sr} = 29.95\ \%$

$Sr(No_3)_2$ Carrier + Sr-90 tracer:

GA Tech Detector –

sample (Date)	Carrier (ml)	Weight of precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
1 (7/7/88)	1.0	29.39	83.76	4899	6.08
* 2 (7/21/88)	"	28.80	82.05	—	—
3 (7/28/88)	"	29.88	85.13	5672	6.75
4 (9/1/88)	"	31.38	89.40	5628	5.6

* Some of ppt. was lost while mounting, It was not used to plot.

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7/7/88)	1.0	12390	438.18	26.72	49.73
* 2 (7/21/88)	s	—	—	—	—
3 (7/28/88)	s	12692	446.85	30.89	46.31
4 (9/1/88)	s	13000	449.0	29.64	45.76

Sample Calculation :

Total Initial Gross Count = 4899

Initial Time (t_i) = 6.08 hr

Total Final Gross Count = 12390

Final Time (t_f) = 438.18 hr

Activity of Sr-90 (A_{Sr-90}) = 387.48 dpm/ml

% yield = 83.76

$$A_{Sr-90} = (179.2\ pCi/ml)\left(e^{\frac{-(0.693)(397)}{28.6 \times 365}}\right)(2.22\ dpm/pCi) = 387.48\ dpm/ml$$

$BKG_i = 50.37$, $BKG_f = 54.6$

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{4899 - 50.37}{50} = 96.97\ CPM$$

$$R_f = \frac{12390 - 54.6}{50} = 246.71\ CPM$$

① $$\frac{96.97}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(6.08)}{64.2}}\right)$$

② $$\frac{246.71}{(387.48)(0.8376)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(438.18)}{64.2}}\right)$$

① $\times -1$ { $0.2987629 = \epsilon_{sr} + 0.0635226\ \epsilon_y$ }

② $0.7601033 = \epsilon_{sr} + 0.9911725\ \epsilon_y$

$0.4613403 = 0.9276499\ \epsilon_y$

$\epsilon_y = 49.73\%$
$\epsilon_{sr} = 26.72\%$

$Sr(NO_3)_2$ carrier + Sr-90 tracer:

GA Tech Detector—

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
1 (7/11/88)	1.25	40.95	93.3	5020	4.45
2 (7/17/88)	"	38.68	88.2	5387	5.33
3 (9/1/88)	"	40.82	93.04	5408	6.43

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
1 (7/11/88)	1.25	11916	418.85	25.60	40.48
2 (7/17/88)	"	13158	465.17	28.56	48.55
3 (9/1/88)	"	13613	449.83	26.52	49.38

Sample Calculation :

Total Initial Gross Count = 5020

Initial Time (t_i) = 4.45 hr

Total Final Gross Count = 11916

Final Time (t_f) = 418.85 hr

Activity of sr-90 (A_{sr-90}) = 387.37 dpm/ml

% yield = 93.3

$$A_{sr-90} = (179.2\ pCi/ml)\left(e^{\frac{-(0.693)(401)}{28.6 \times 365}}\right)(2.22) = 387.37\ dpm/ml$$

$BKG_i = 50.66$, $BKG_f = 53.6$

$$\text{①}\quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$\text{②}\quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{5020 - 50.66}{50} = 99.39 \quad CPM$$

$$R_f = \frac{11916 - 53.6}{50} = 237.25 \quad CPM$$

$$\text{①}\quad \frac{99.39}{(387.37)(0.933)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(4.45)}{64.2}}\right)$$

$$\text{②}\quad \frac{237.25}{(387.37)(0.933)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(418.85)}{64.2}}\right)$$

$$\text{①} \times -1\left\{0.2750015 = \epsilon_{sr} + 0.0468996\,\epsilon_y\right\}$$

$$\text{②}\quad 0.6564453 = \epsilon_{sr} + 0.9891243\,\epsilon_y$$

$$0.3814438 = 0.9422247\,\epsilon_y$$

$\epsilon_y = 40.48\ \%$
$\epsilon_{sr} = 25.60\ \%$

$Sr(No_3)_2$ Carrier + Sr-90 tracer :

GA Tech Detector—

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time(t_i) (hr)
* 1 (7/11/88)	1.50	53.65	>100	—	—
2 (7/17/88)	〃	45.64	86.7	5032	6.17
3 (7/28/88)	〃	44.12	83.80	5153	7.65
4 (9/6/88)	〃	45.82	87.03	5188	4.1
5 (9/6/88)	〃	42.92	81.52	4888	4.95

* It was not used to plot

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
* 1 (7/11/88)	1.50	—	—	—	—
2 (7/17/88)	"	12103	466.0	26.78	45.34
3 (7/28/88)	"	12442	447.68	27.58	49.32
4 (9/6/88)	"	12335	332.82	28.61	45.80
5 (9/6/88)	"	11808	333.65	28.27	47.78

Sample Calculation:

Total Initial Gross Count = 5032

Initial Time (t_i) = 6.17 hr

Total Final Gross count = 12103

Final Time (t_f) = 466.0 hr

Activity of sr-90 (A_{sr-90}) = 387.22 dPM/ml

% yield = 86.7

$$A_{sr-90} = (179.2\ PCi/ml)\left(e^{-\frac{(0.693)(407)}{28.6\times365}}\right)(2.22\ dPM/PCi) = 387.22\ dPM/ml$$

$BKG_i = 46.25$ $BKG_f = 44.25$

$$① \quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$② \quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{5032 - 46.25}{50} = 99.71\ CPM$$

$$R_f = \frac{12103 - 44.25}{50} = 241.13\ CPM$$

$$① \quad \frac{99.71}{(387.22)(0.867)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(6.17)}{64.2}}\right)$$

$$② \quad \frac{241.13}{(387.22)(0.867)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(466)}{64.2}}\right)$$

$$① \quad -1\{0.2970036 = \epsilon_{sr} + 0.064342\ \epsilon_y\}$$

$$② \quad 0.7182479 = \epsilon_{sr} + 0.9934147\ \epsilon_y$$

$$0.4212443 = 0.9290727\ \epsilon_y$$

$\epsilon_y = 45.34\%$
$\epsilon_{sr} = 26.78$

$Sr(NO_3)_2$ Carrier + sr-90 tracer:

GA Tech Detector –

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
* 1 (7/11/88)	1.75	62.13	>100	4501	—
2 (7/17/88)	"	54.73	89.1	5091	7.0
3 (9/6/88)	"	53.15	86.53	4906	5.78
4 (9/6/88)	"	55.32	90.06	5064	6.63

* It was not used to plot

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of sr-90	% Efficiency (ϵ) of y-90
* 1 (7/11/88)	1.75	—	—	—	—
2 (7/17/88)	"	12597	467.25	25.80	47.27
3 (9/6/88)	"	12404	334.48	26.11	49.21
4 (9/6/88)	"	12583	335.32	25.55	47.86

Sample Calculation :

Total Initial Gross Count = 5091

Initial Time (t_i) = 7.0 hr

Total Final Gross Count = 12597

Final Time (t_f) = 467.25 hr

Activity of sr-90 (A_{sr-90}) = 387.22

% yield = 89.1

$$A_{sr-90} = (179.2\ pCi/ml)\left(e^{\frac{(0.693)(467)}{28.6 \times 365}}\right)(2.22\ dpm/pCi) = 387.22\ dpm/ml$$

$BKG_i = 46.25$, $BKG_f = 44.25$

① $$\frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

② $$\frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{5091 - 46.25}{50} = 100.89\ CPM$$

$$R_f = \frac{12597 - 44.25}{50} = 251.05\ CPM$$

① $$\frac{100.89}{(387.22)(0.891)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(7.0)}{64.2}}\right)$$

② $$\frac{251.05}{(387.22)(0.891)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{\frac{-(0.693)(467.25)}{64.2}}\right)$$

① $\times -1$ $\{0.2924237 = \epsilon_{sr} + 0.0727765\ \epsilon_y\}$

② $0.7276537 = \epsilon_{sr} + 0.99355\ \epsilon_y$

$0.43523 = 0.9207735\ \epsilon_y$

$\epsilon_y = 47.27\ \%$
$\epsilon_{sr} = 25.80\ \%$

$Sr(NO_3)_2$ Carrier + Sr-90 tracer:

GA Tech Detector –

Sample (Date)	Carrier (ml)	Weight of Precipitate (mg)	% yield	Total Initial Gross Count (50 min)	Initial Time (t_i) (hr)
1 (7/11/88)	2.0	67.51	96.2	4680	6.97
* 2 (7/28/88)	"	61.41	87.48	—	—
3 (9/6/88)	"	63.04	89.80	4881	7.22
4 (9/6/88)	"	65.64	93.50	5140	8.05

* A small amount of sample was lost while mounting.
* It was not used to plot.

Sample (Date)	Carrier (ml)	Total Final Gross Count (50 min)	Final Time (t_f) (hr)	% Efficiency (ϵ) of Sr-90	% Efficiency (ϵ) of Y-90
1 (7/11/88)	2.0	12316	452.3	21.88	44.53
* 2 (7/28/88)	s	—	—	—	—
3 (9/6/88)	s	12616	335.92	24.15	49.69
4 (9/6/88)	s	12485	336.33	24.41	45.73

Sample Calculation :

Total Initial Gross Count = 4680

Initial Time (t_i) = 6.97 hr

Total Final Gross Count = 12316

Final Time (t_f) = 452.3 hr

Activity of sr-90 (A_{sr-90}) = 387.37 dpm/ml

% yield = 96.2

$$A_{sr-90} = (179.2\ \text{pci/ml})\left(e^{-\frac{(0.693)(401)}{28.6\times 365}}\right)(2.22\ \text{dpm/pci}) = 387.37\ \text{dpm/ml}$$

$BKG_i = 50.66$, $BKG_f = 53.6$

$$\text{①}\quad \frac{R_i}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{-\frac{(0.693)(t_i)}{t_{1/2}\text{ of y}}}\right)$$

$$\text{②}\quad \frac{R_f}{(A_{sr})(\text{yield of sr})} = \epsilon_{sr} + \epsilon_y\left(1 - e^{-\frac{(0.693)(t_f)}{t_{1/2}\text{ of y}}}\right)$$

$$R_i = \frac{4680 - 50.66}{50} = 92.59\ \text{CPM}$$

$$R_f = \frac{12316 - 53.6}{50} = 245.25\ \text{CPM}$$

$$\text{①}\quad \frac{92.59}{(387.37)(0.962)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{-\frac{(0.693)(6.97)}{64.2}}\right)$$

$$\text{②}\quad \frac{245.25}{(387.37)(0.962)} = \epsilon_{sr} + \epsilon_y\left(1 - e^{-\frac{(0.693)(452.3)}{64.2}}\right)$$

$$\text{①} \times -1\left\{0.2484637 = \epsilon_{sr} + 0.0724762\,\epsilon_y\right\}$$

$$\text{②}\quad 0.6581243 = \epsilon_{sr} + 0.9924204\,\epsilon_y$$

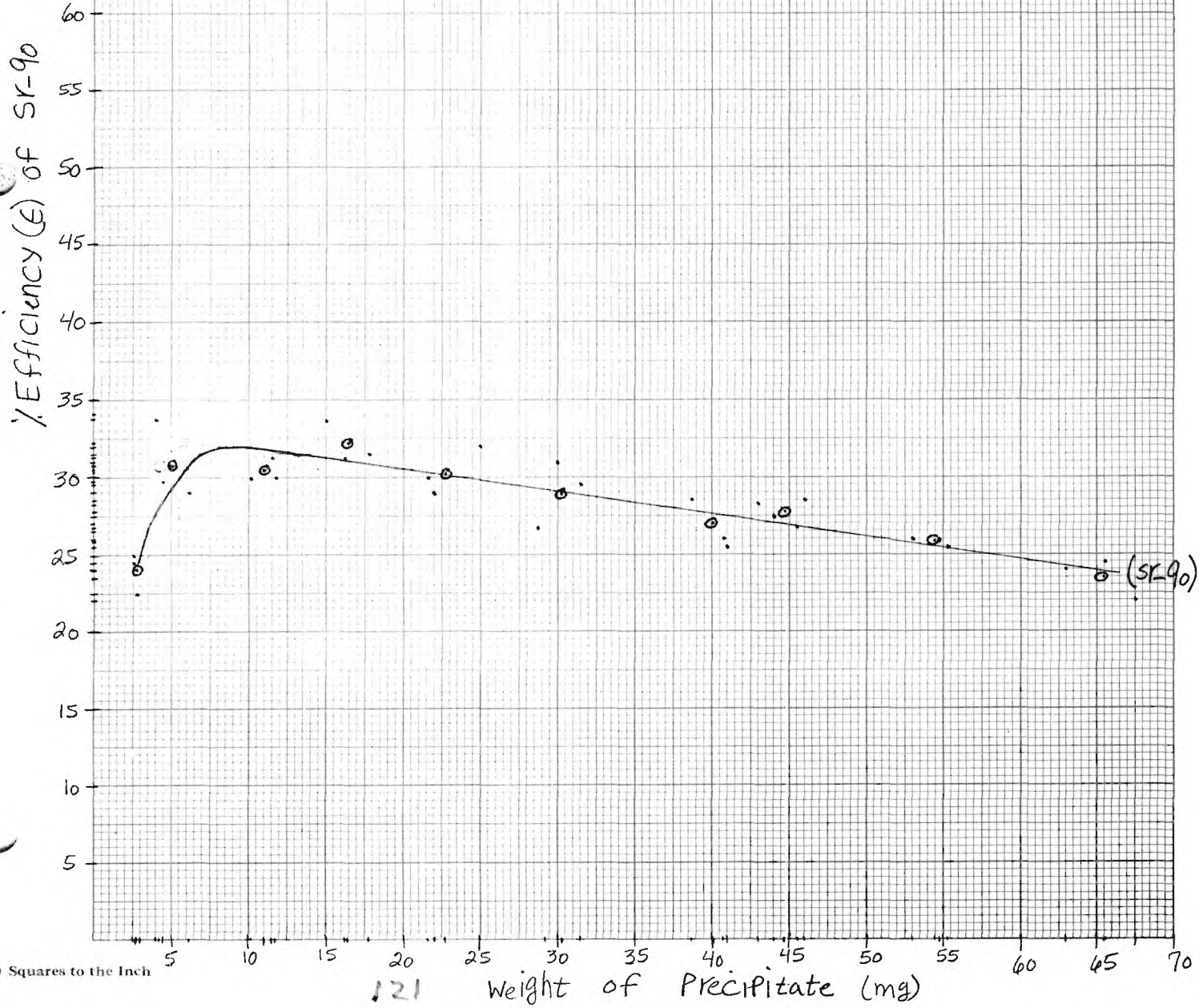
$$0.4096606 = 0.9199442\,\epsilon_y$$

$\epsilon_y = 44.53\ \%$
$\epsilon_{sr} = 21.88\ \%$

GA Tech Detector

⊙ Average Value (Sr-90)

Figure #6



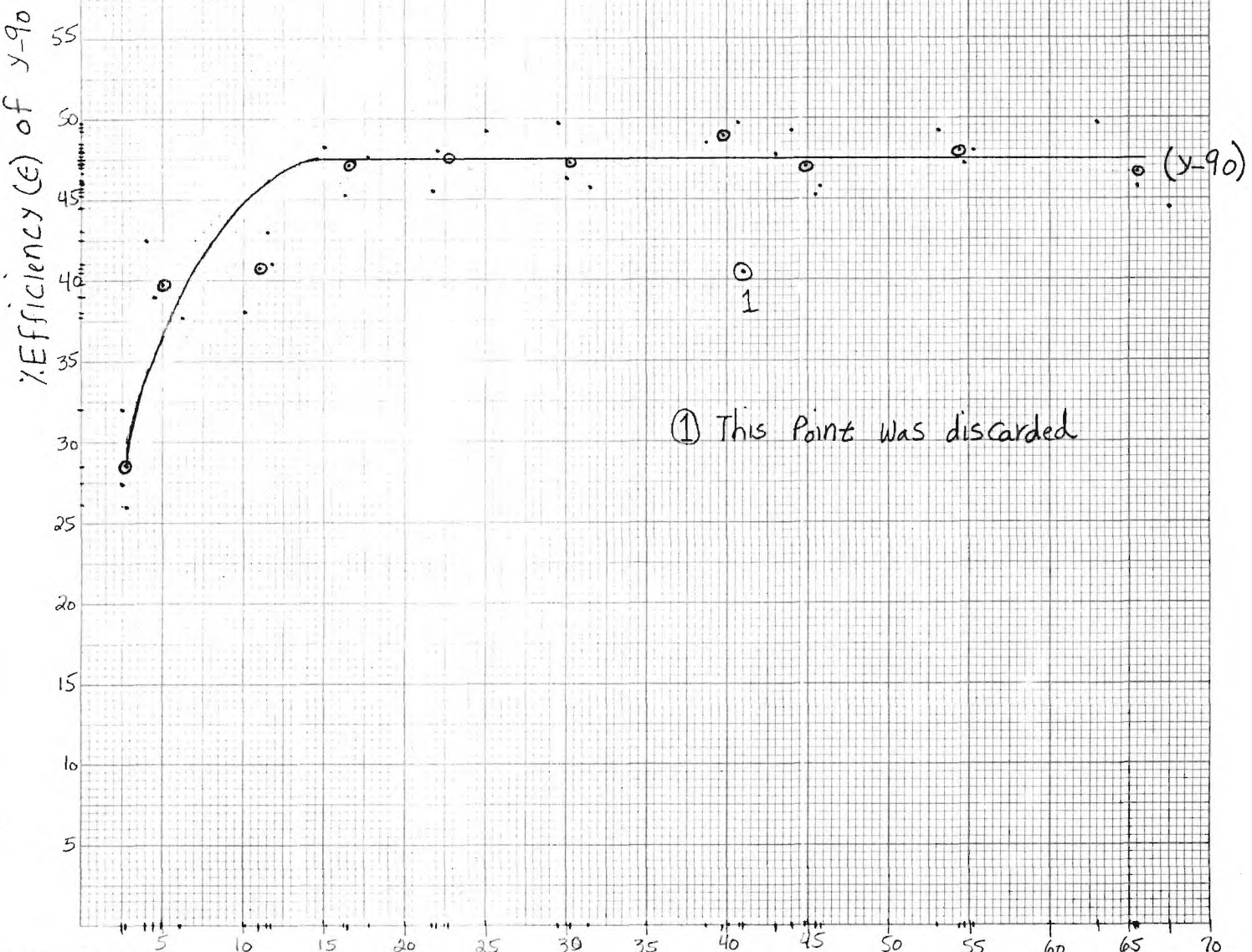
20 Squares to the Inch

121

GA Tech Detector

⊙ Average Value (y-90)

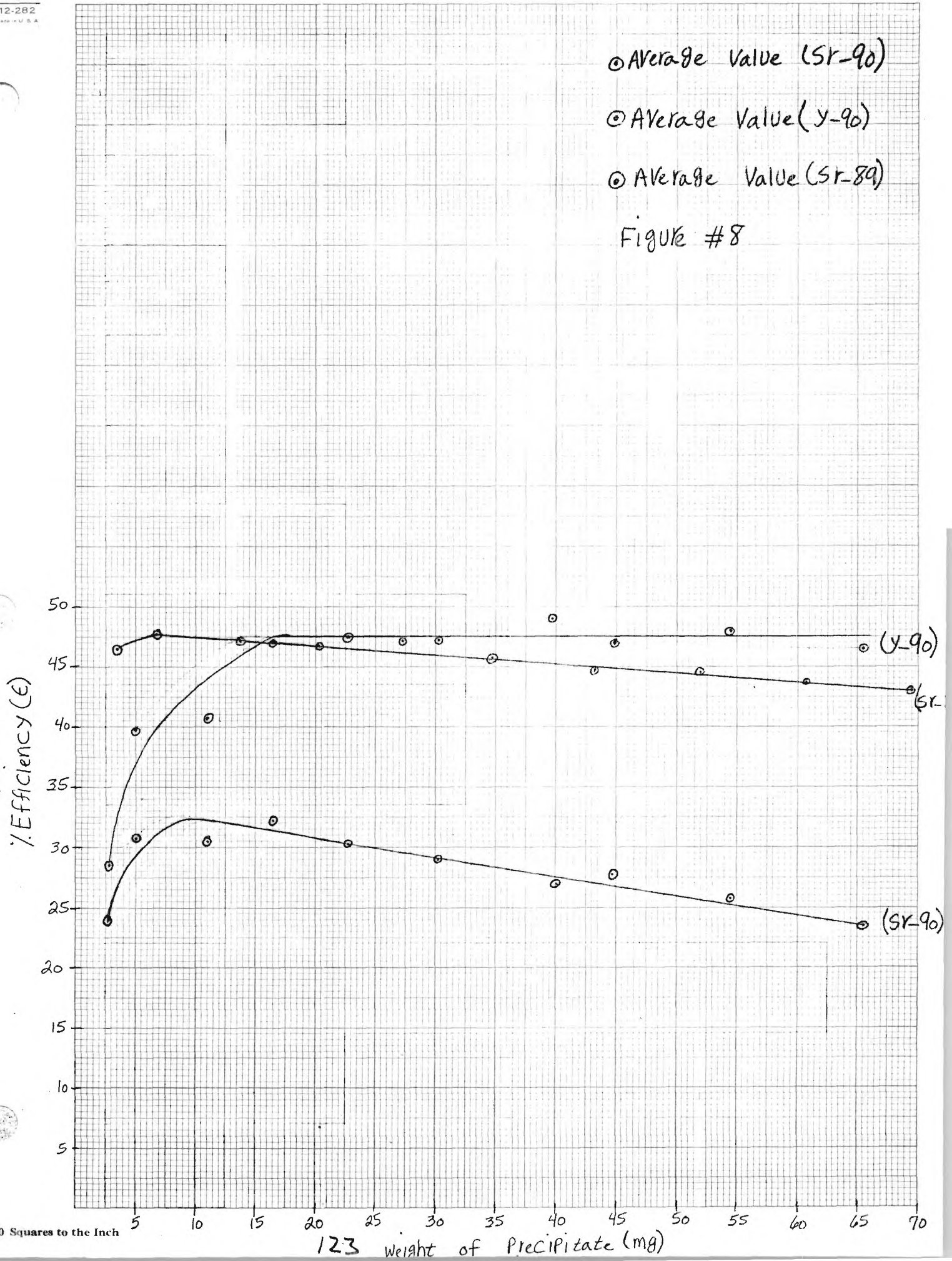
Figure #7



① This Point was discarded

20 Squares to the Inch

GA Tech Detector



20 Squares to the Inch